

# Expectations to GPM Mission from JMA/NWP

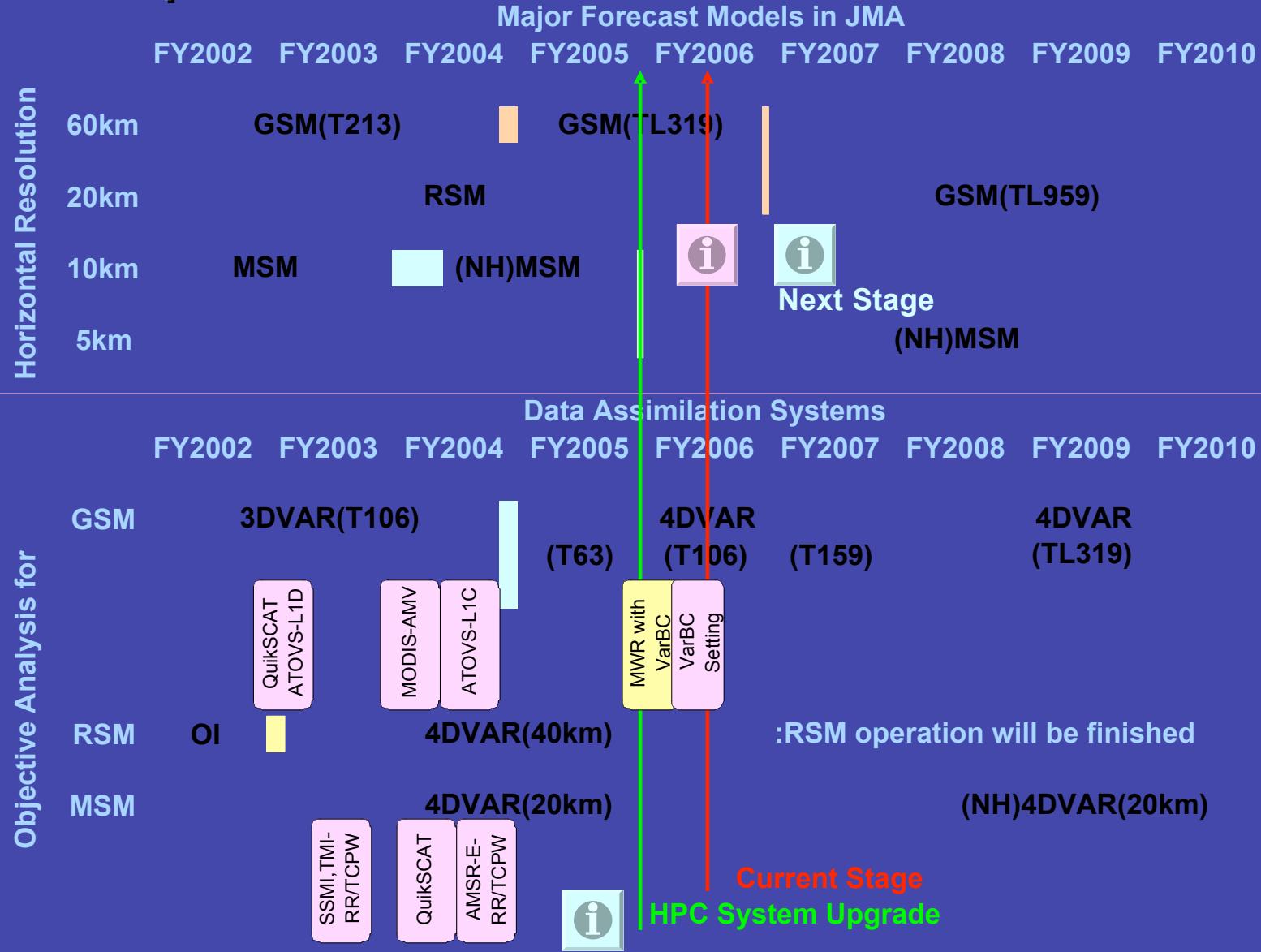
Yoshiaki SATO  
JMA/NPD

The 6th International GPM Planning Workshop  
6-8 November, 2006, Annapolis

# Contents

- Update and Plan of JMA/NWP
- MWR data utilization on JMA/NWP
- Request for the mission

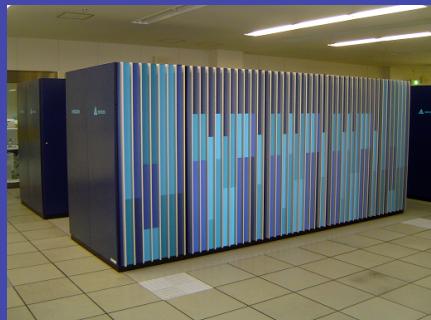
# Update and Plan of JMA/NWP



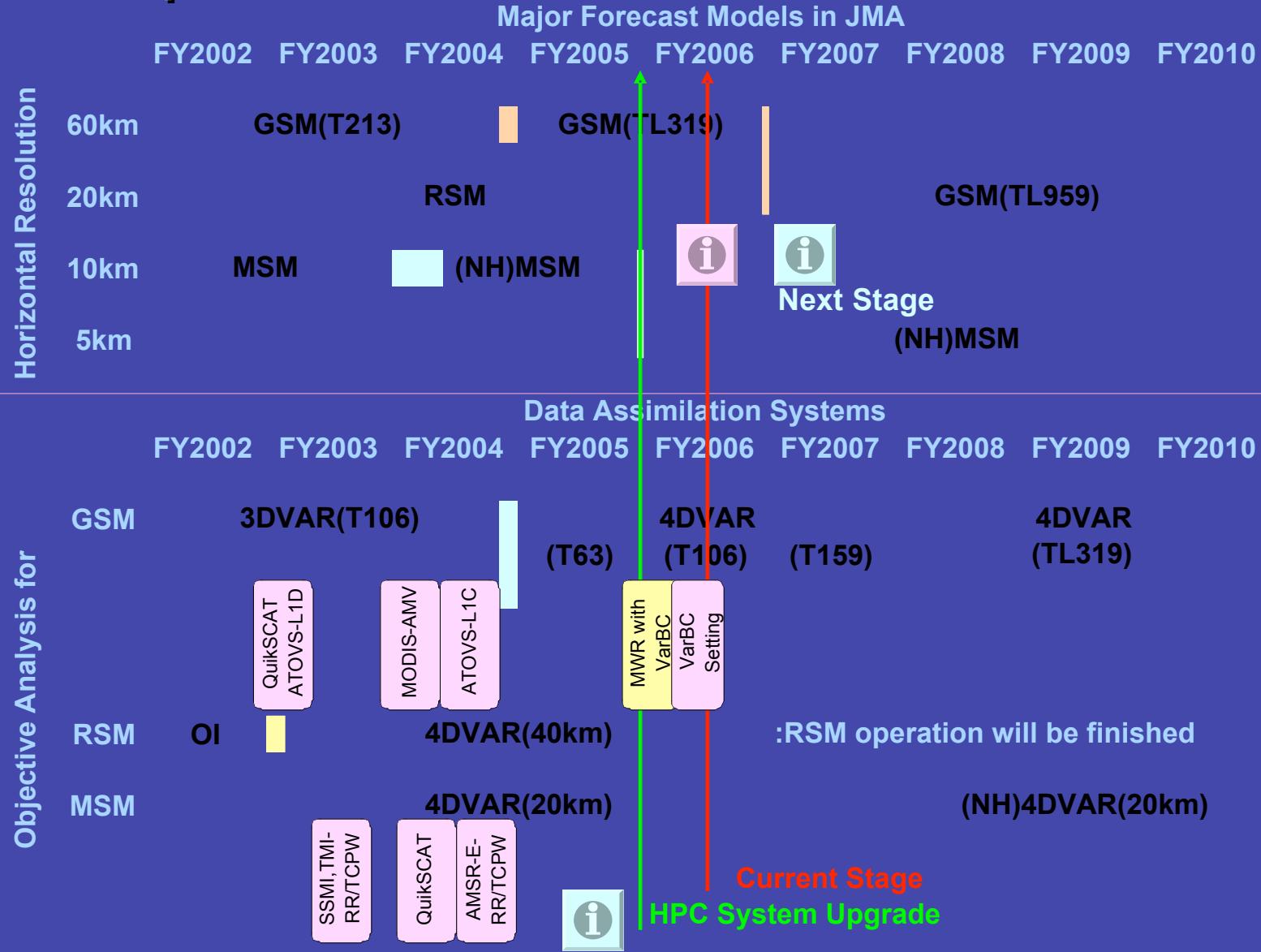
# JMA HPC SYSTEM

- Updated on 1 Mar. 2006

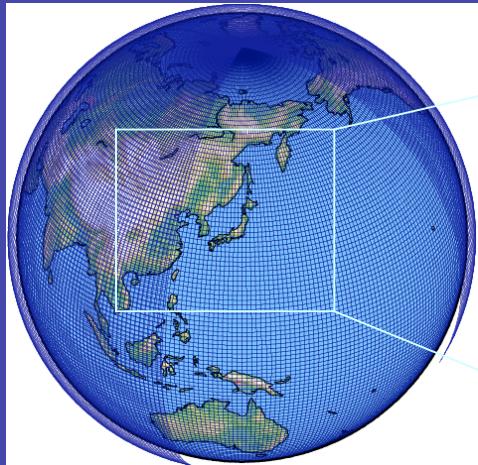
	NAPS8	NAPS7
DATE	2006.3.1~	2001.3.1~
SYSTEM	HITACHI SR11000 K1	HITACHI SR8000 E1
CPU/NODE	16	8
NODE	80Node x2	80NODE
Performance	21.5 TFLOPS	768 GFLOPS
Memory	10.0 TB	640GB



# Update and Plan of JMA/NWP



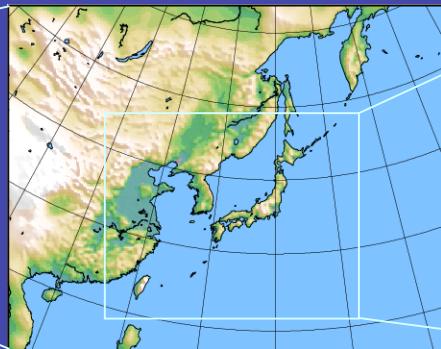
# Current Operational Models in JMA



GSM  
TL319 (60km)  
L40 (~0.4hPa)

4 times/day  
36, 90 and 216 hrs fcst

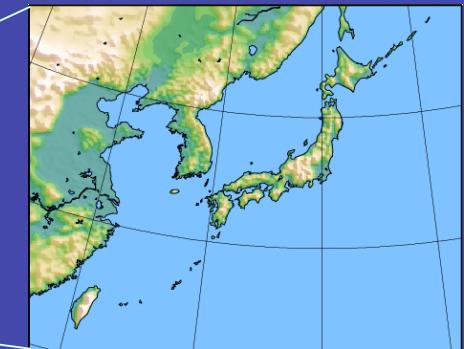
DA system  
4DVAR (T106)  
(Updated on Mar. 2006)



RSM  
 $\Delta x=20\text{km}$   
L40 (~10hPa)

2 times/day  
51 hrs fcst

DA system  
4DVAR (40km)



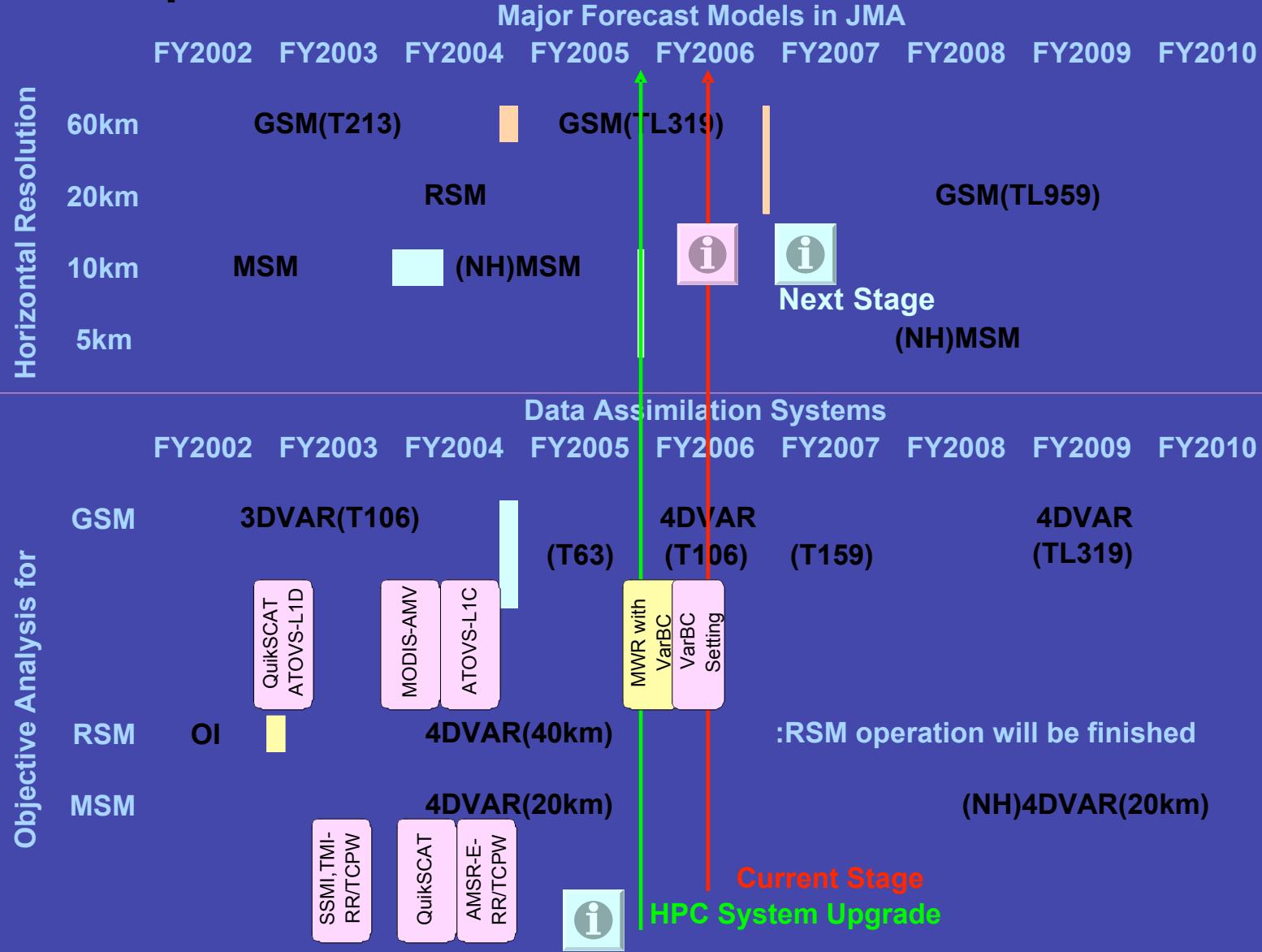
MSM  
 $\Delta x=5\text{km}$   
L50 (~22km)  
(Updated on Mar. 2006)

8 times/day  
15 hrs fcst

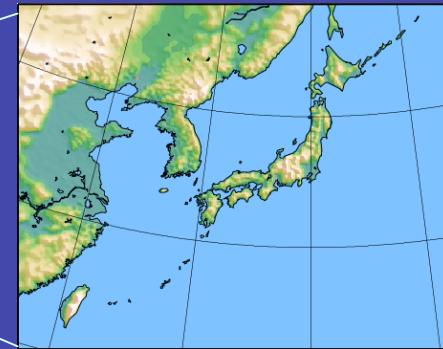
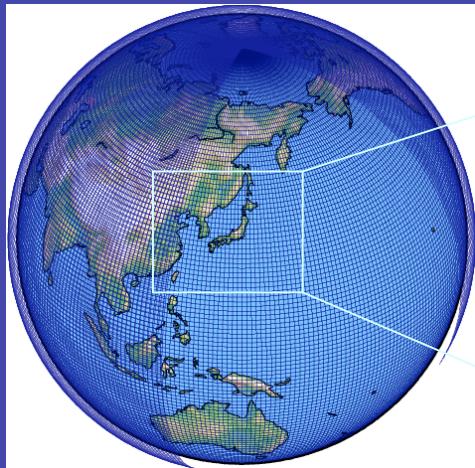
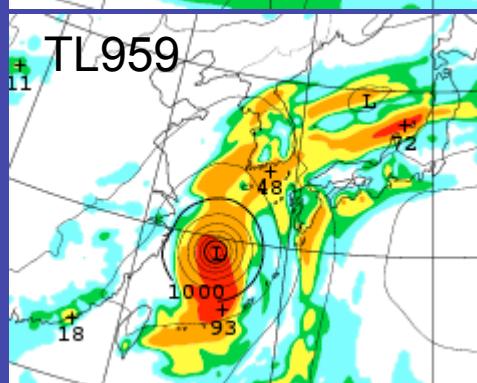
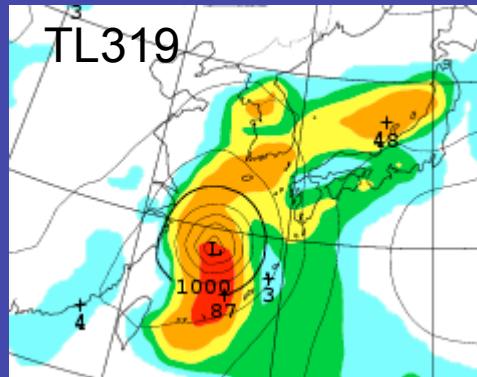
DA system  
4DVAR (20km)



# Update and Plan of JMA/NWP



# Next Operational Models in JMA



GSM  
TL959 (20km)  
L60 (~0.1hPa)

4 times/day  
36, 90 and 216 hrs fcst

DA system  
4DVAR (T159)

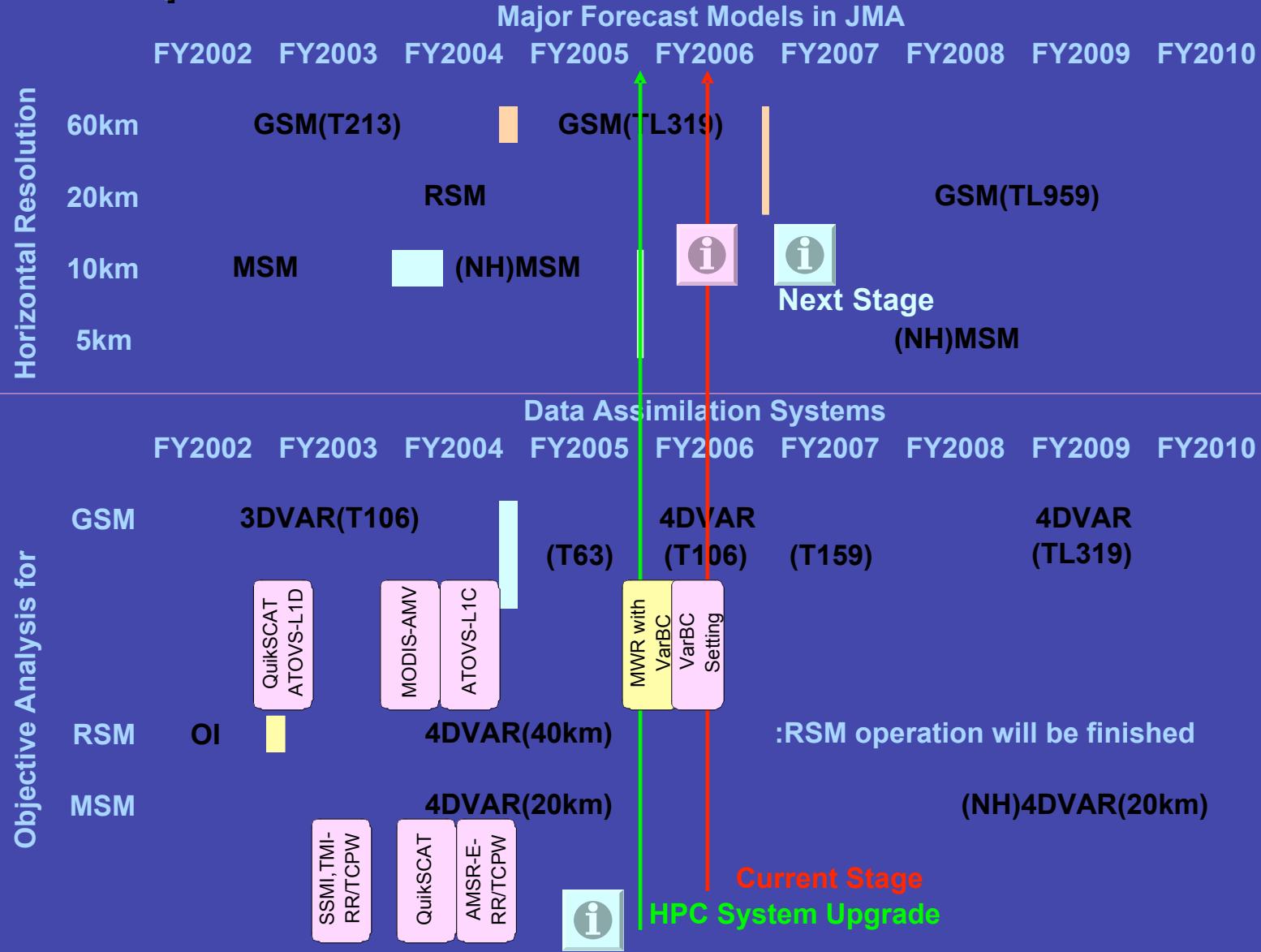
MSM  
 $dx=5\text{km}$   
L50 (~22km)

8 times/day  
15, 33 hrs fcst

DA system  
4DVAR (20km)



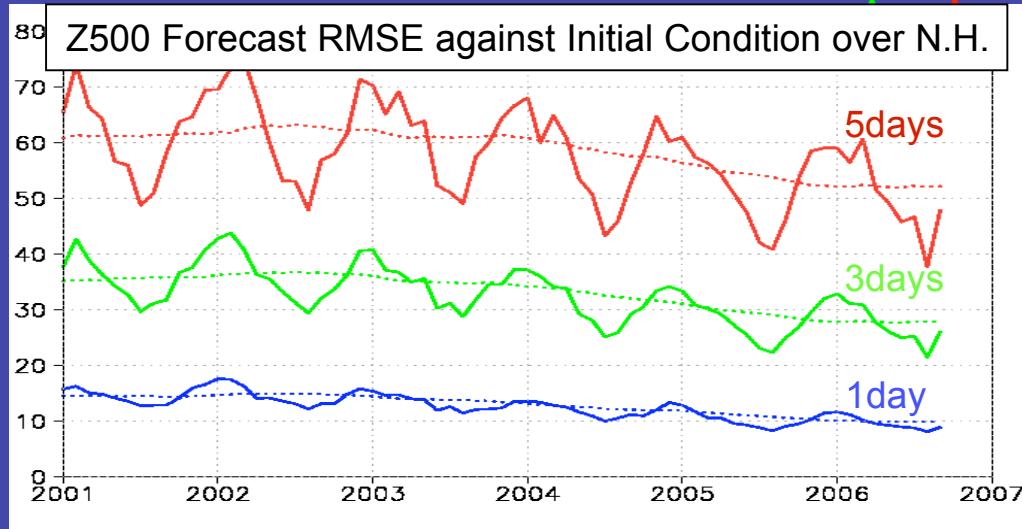
# Update and Plan of JMA/NWP



# Update and Plan of JMA/NWP

## Major Forecast Models in JMA

FY2002 FY2003 FY2004 FY2005 FY2006 FY2007 FY2008 FY2009 FY2010



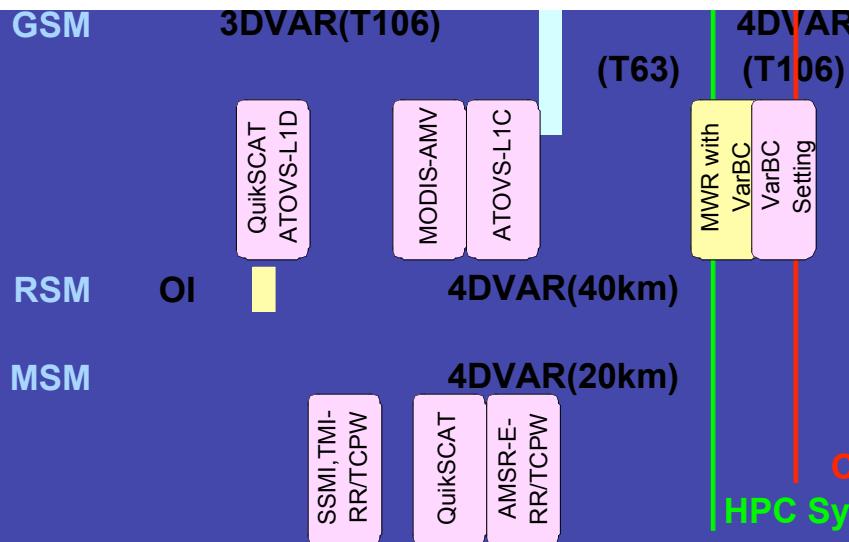
GSM(TL959)

(NH)MSM

## Systems

FY2007 FY2008 FY2009 FY2010

Objective Analysis for



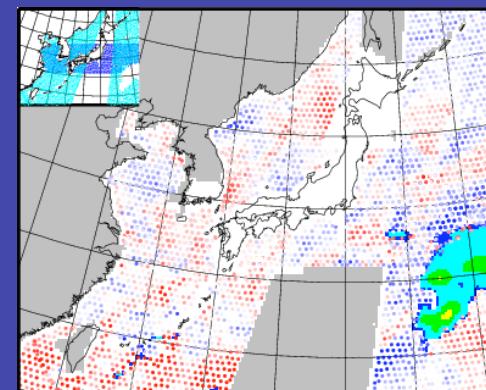
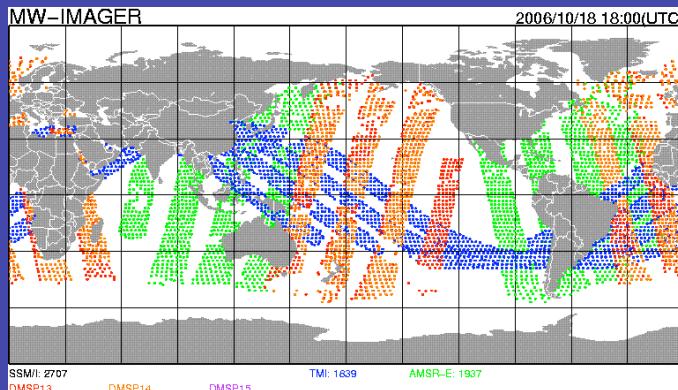
RSM operation will be finished

Current Stage

HPC System Upgrade

# MWR data utilization status

	GSM (4D-Var) 	MSM (4D-Var)
Assimilated Data	Radiance (Clear Sky Region)	Precipitable Water, Rain Rate
Sensor, Date	SSM/I, TMI, AMSR-E: May 2006 -	SSM/I, TMI: Oct 2003 - AMSR-E: Nov 2004 -
Ocean Boundary	(MGDSST: 2007-)	MGDSST: Mar 2006 -



**OSE Result (RAIN)**

**Assim-Sample**

**OSE Result (FCST)**

**Status**

**Sample Case**

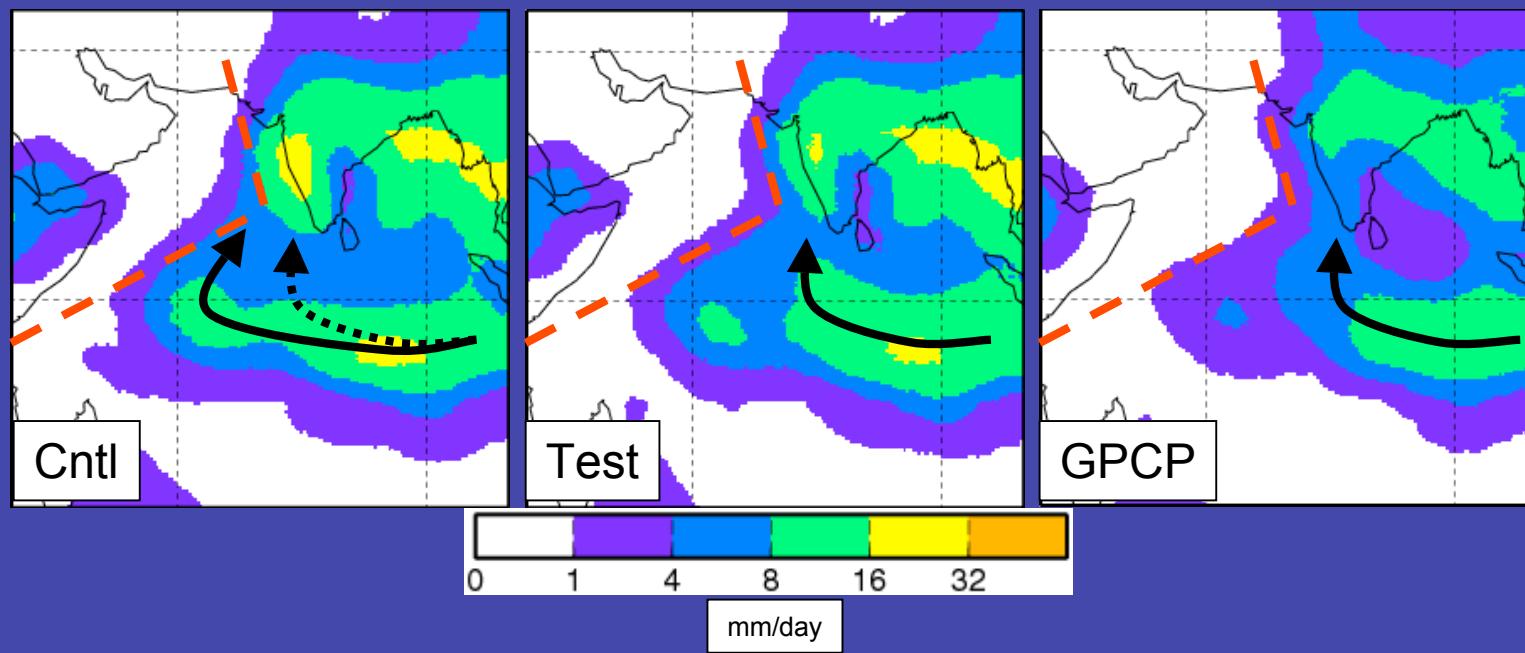
**Assim-Sample**

**Data Distribution**

\*MGDSST: analyzed SST using AVHRR, AMSR-E and in situ data

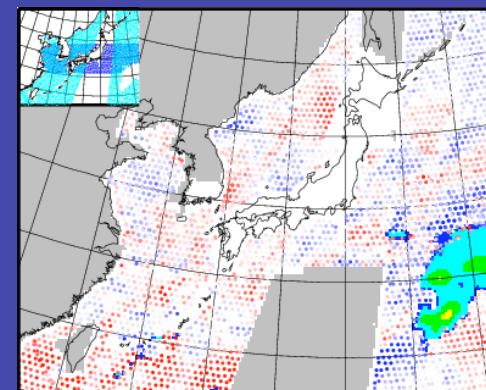
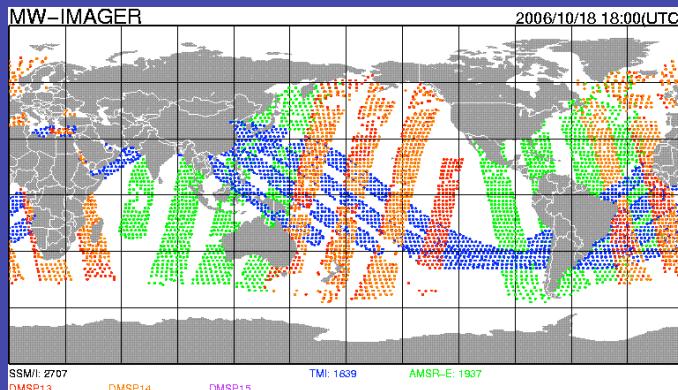
# OSE results

- Monthly averaged daily rainfall amount
  - Correlations against GPCP:
    - Cntl:0.881 → Test:0.891 (Aug)
    - Cntl:0.835 → Test:0.841 (Jan)
  - The lower figures show the data on Aug 2004.



# MWR data utilization status

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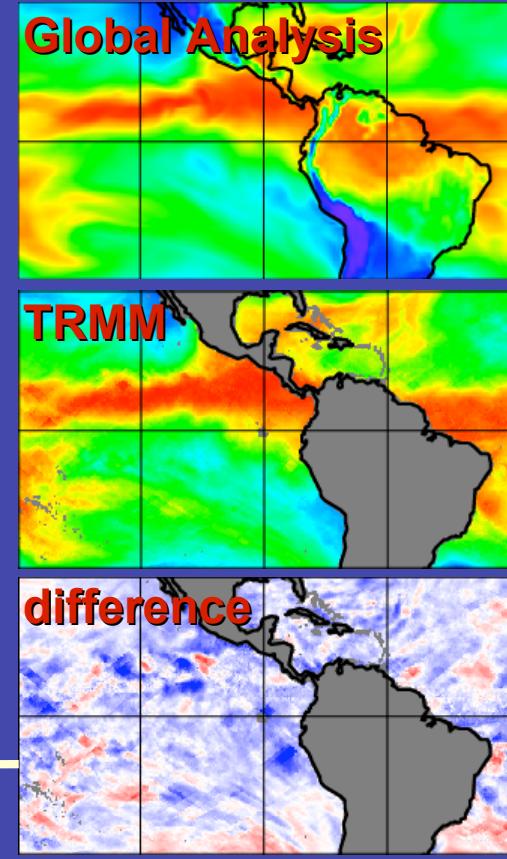
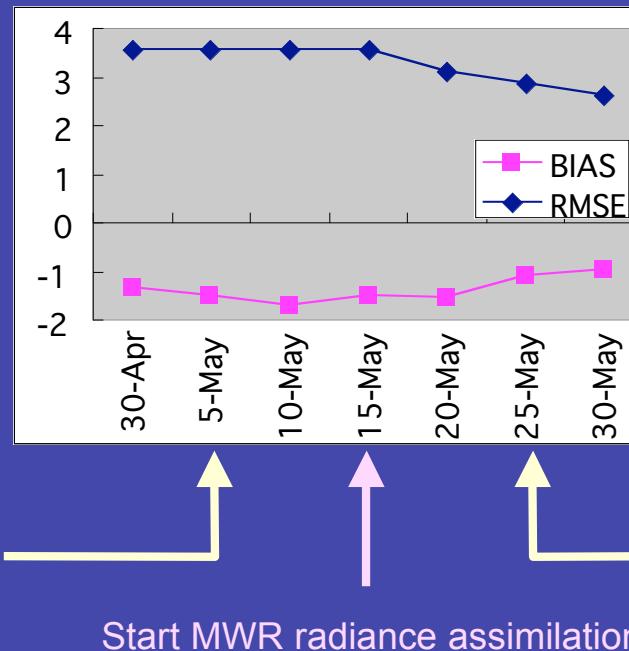
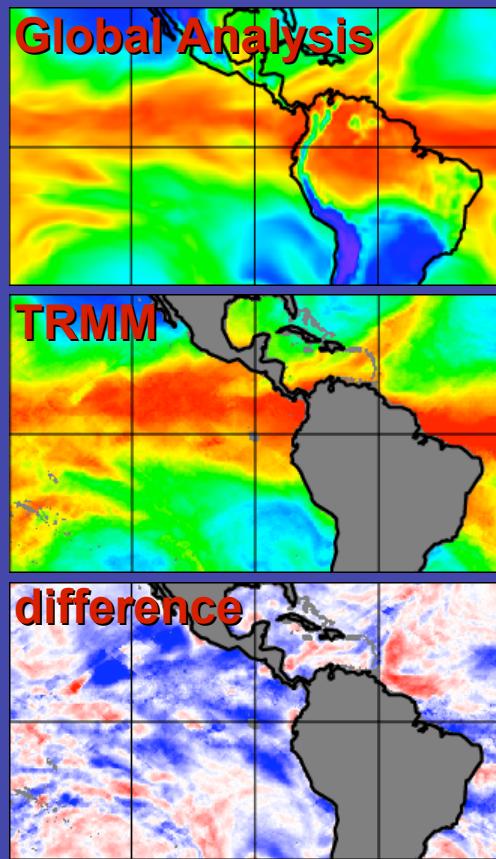
Assim-Sample

Data Distribution

\*MGDSST: analyzed SST using AVHRR, AMSR-E and in situ data

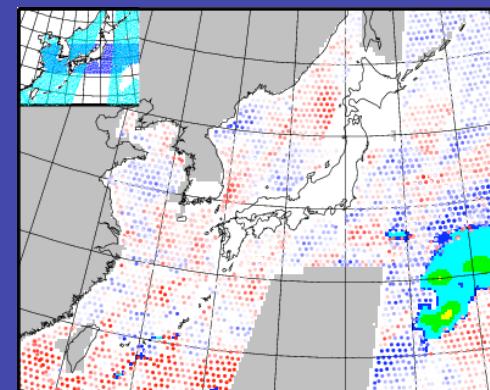
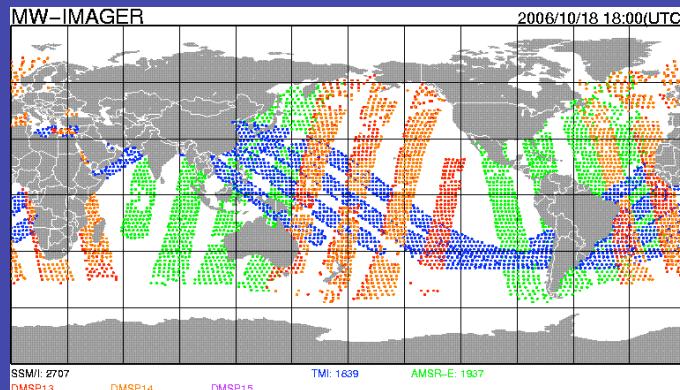
# MWR Assimilation Status

- Compared with TRMM 3-day-averaged TCPW



# MWR data utilization status

	GSM (4D-Var) 	MSM (4D-Var)
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**OSE Result (RAIN)**

**Assim-Sample**

**OSE Result (FCST)**

**Status**

**Sample Case**

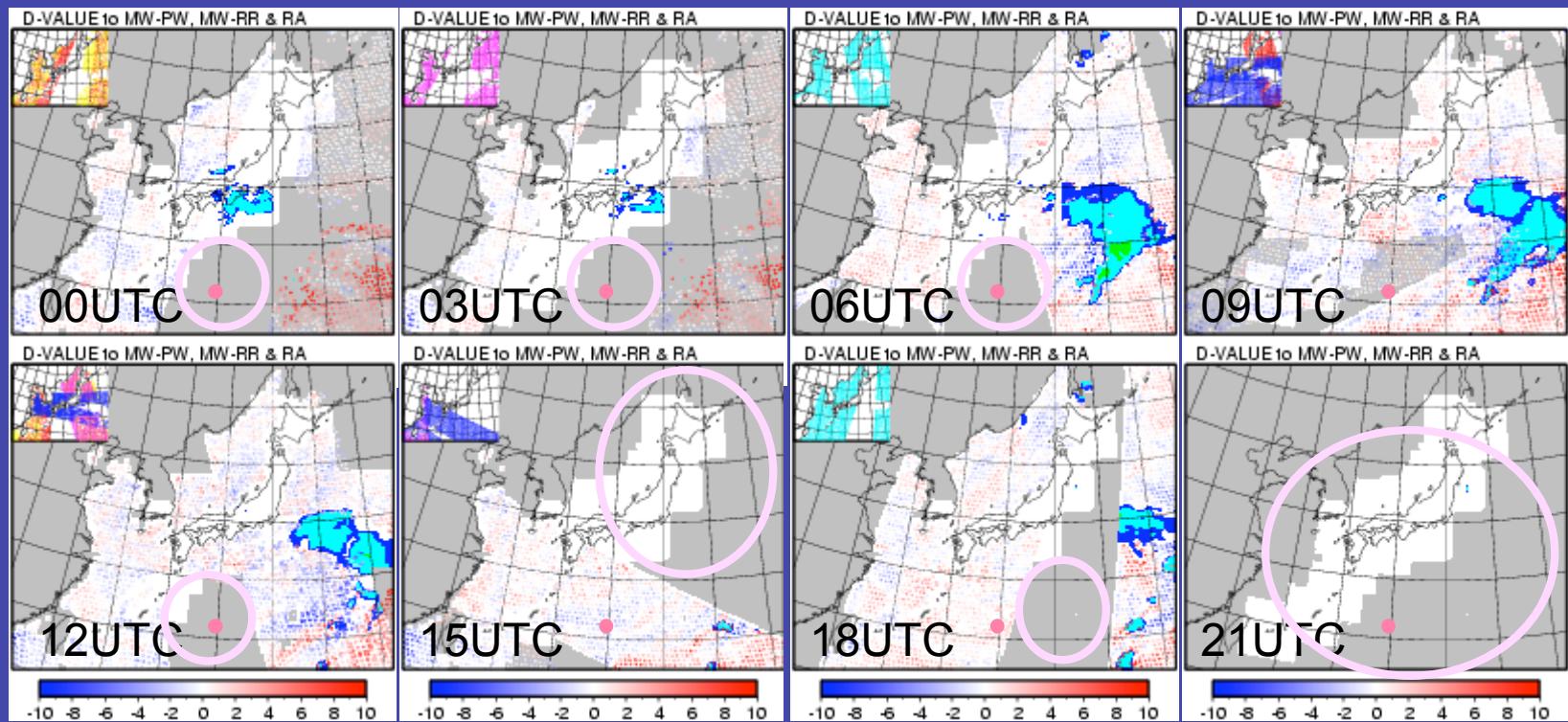
**Assim-Sample**

**Data Distribution**

\*MGDSST: analyzed SST using AVHRR, AMSR-E and in situ data

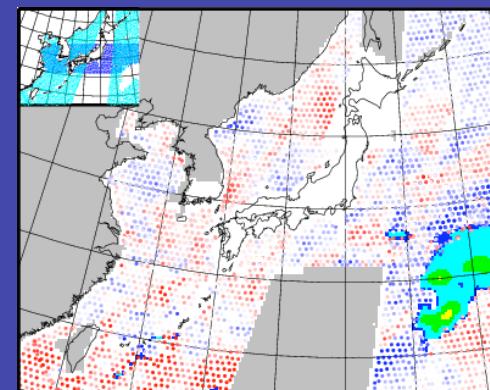
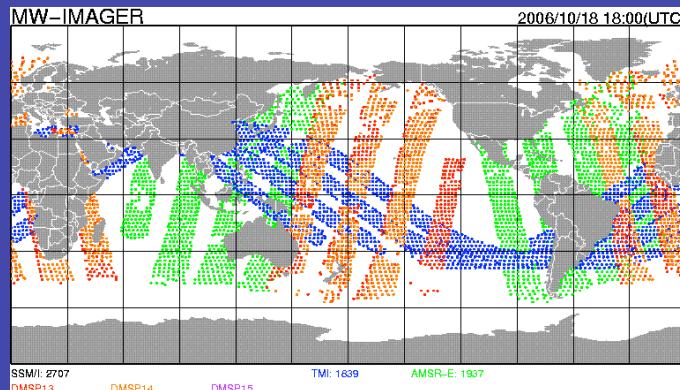
# Data Distribution Sample for MSM

- 10 Mar. 2006
  - There are some places where no MWR data were distributed
    - → The increase of observation frequency is highly expected



# MWR data utilization status

	GSM (4D-Var) 	MSM (4D-Var)
Assimilated Data	Radiance (Clear Sky Region)	Precipitable Water, Rain Rate
Sensor, Date	SSM/I, TMI, AMSR-E: May 2006 -	SSM/I, TMI: Oct 2003 - AMSR-E: Nov 2004 -
Ocean Boundary	(MGDSST: 2007-)	MGDSST: Mar 2006 -



**OSE Result (RAIN)**

**Assim-Sample**

**OSE Result (FCST)**

**Status**

**Sample Case**

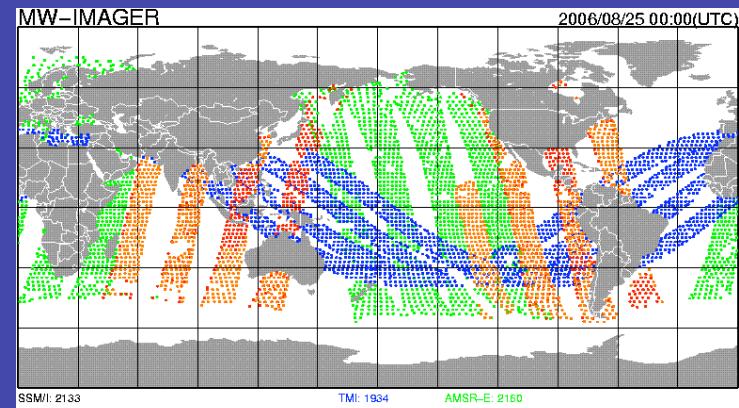
**Assim-Sample**

**Data Distribution**

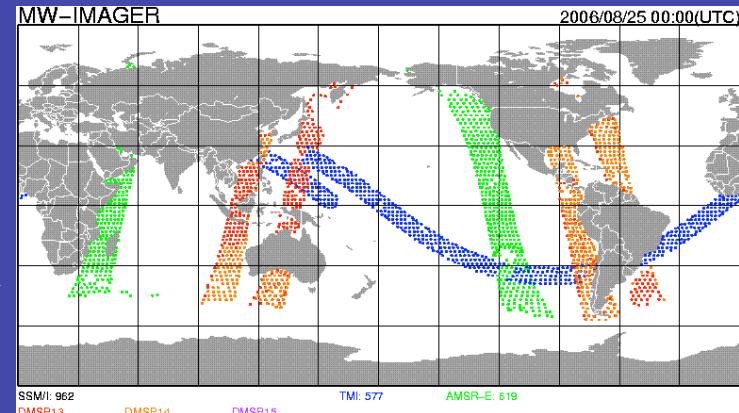
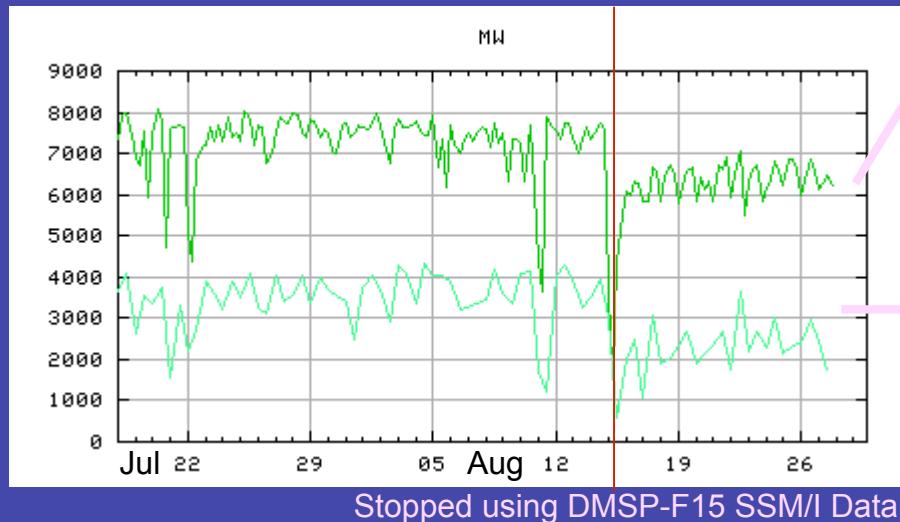
\*MGDSST: analyzed SST using AVHRR, AMSR-E and in situ data

# Used MWR Data Number

- 2 types of Global Analysis
  - Cycle Analysis
    - For Accurate Global Analysis
    - Dealing with Late Delivery Data
  - Early Analysis
    - For Weather Forecast
    - Cannot wait Late Delivery Data



Cycle Analysis

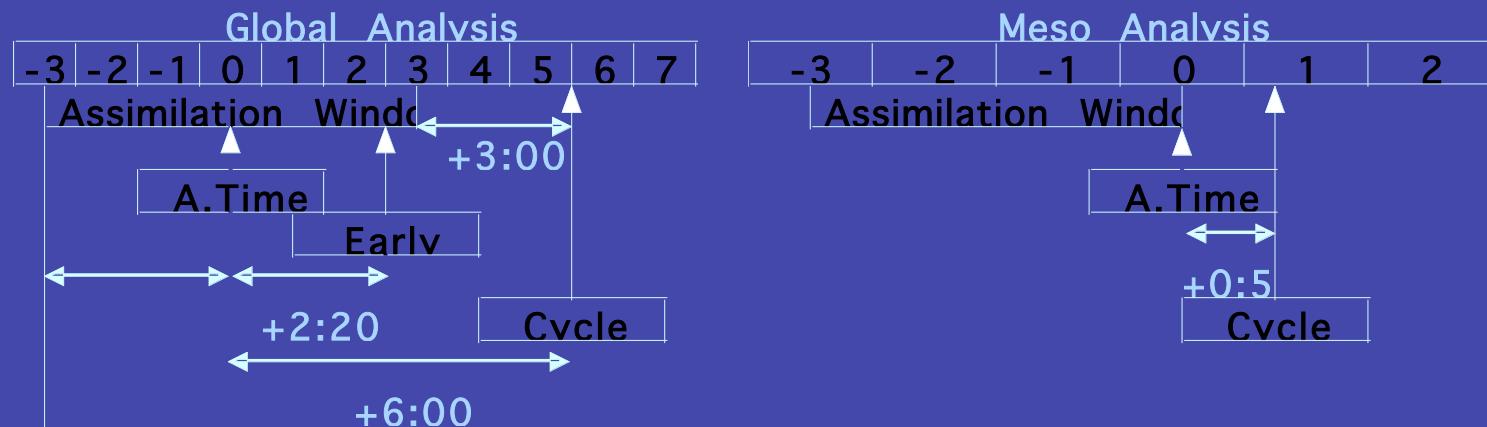


Early Analysis

> Difference

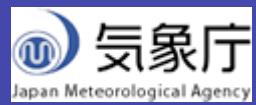
# Requirement for Data Delivery

- Cutoff Time for Data Assimilation
  - MSM: Analysis Time +0:50
  - GSM – Early Analysis: Analysis Time +2:20
  - GSM – Cycle Analysis: Analysis Time +6:00
    - +3:00 from the edge of Assimilation Window



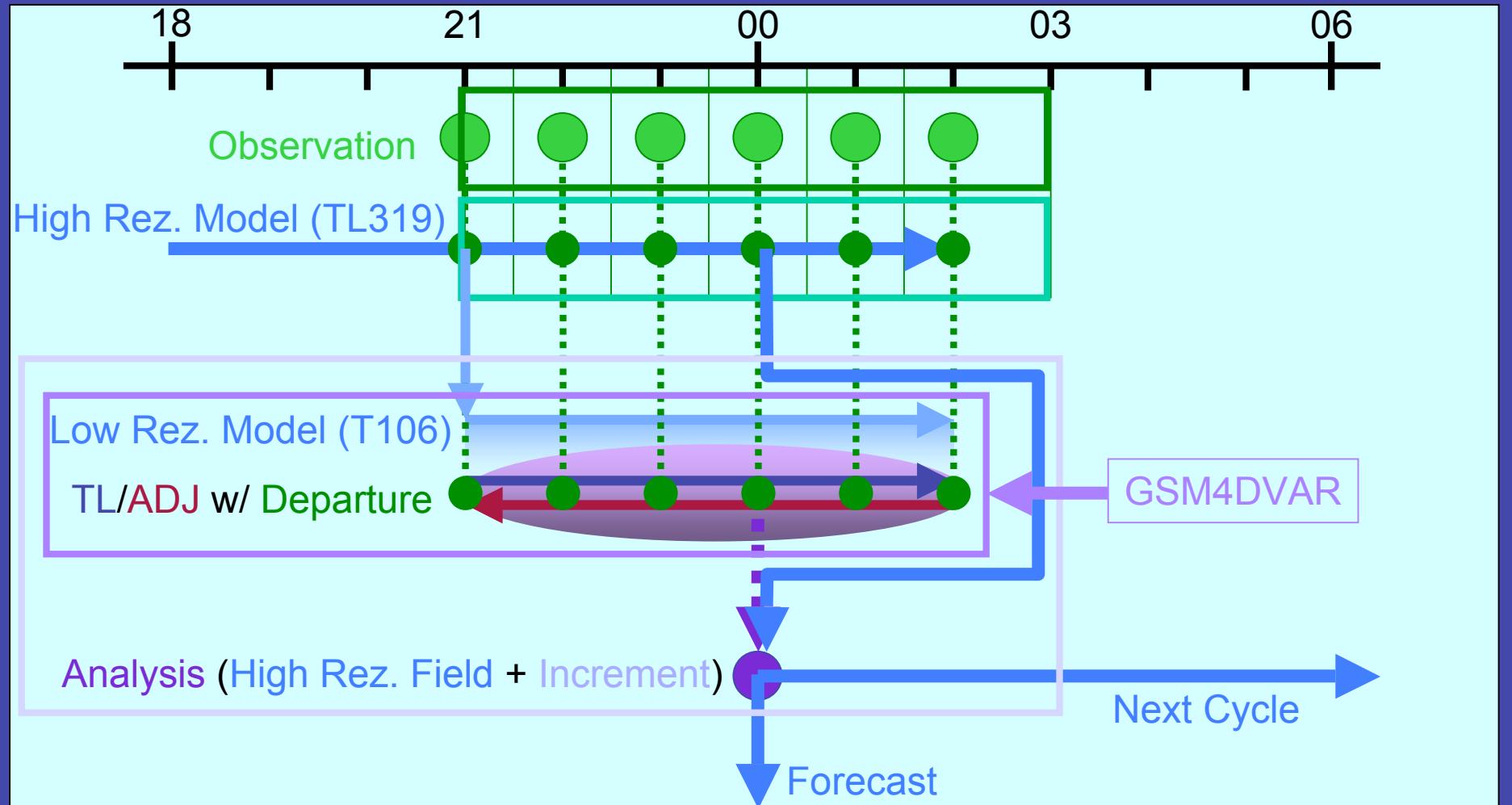
# Summary

- Satellite observations are being contributed for JMA/NWP forecast improvement.
  - About MWR
    - MSM : using retrieved Rain and Precipitable Water
    - GSM : using radiance data over the clear sky ocean
    - OSEs for the both models showed rainfall forecast improvement, especially.
  - Observation frequency is important issue
    - Frequent observation bring more chance to detect heavy rain source → GPM mission is expected to cover this issue.
  - Data latency is very essential for the real-time operation, since no late data can be used.



**Numerical Prediction Division,**  
*Japan Meteorological Agency*

# JMA Global Analysis Flow



# VarBC (Variational Bias Correction)

- Basic Idea (Dee, 2004)
  - Observation Operator includes Bias Correction Term
  - Control Variable includes Bias Correction Coefficients
    - Normal ( $x$ : model variables,  $h(x)$ : observation operator)

$$y = h(\mathbf{x}) \equiv RTM[RTTOV7] \quad \text{For MWR - TB}$$

• Variational Formulation

$$J = (\mathbf{x}_b - \mathbf{x})^T \mathbf{B}^{-1} (\mathbf{x}_b - \mathbf{x}) + (\mathbf{y} - h(\mathbf{x}))^T \mathbf{R}^{-1} (\mathbf{y} - h(\mathbf{x}))$$

$$y = \tilde{h}(\mathbf{z}) \equiv h(\mathbf{x}) + \sum \hat{\mathbf{a}} p(\mathbf{x}_b (\cong \mathbf{x})) \quad \mathbf{z} \equiv [\mathbf{x}, \hat{\mathbf{a}}]$$

$$J = (\mathbf{z}_b - \mathbf{z})^T \mathbf{B}_z^{-1} (\mathbf{z}_b - \mathbf{z}) + (\mathbf{y} - \tilde{h}(\mathbf{x}))^T \mathbf{R}^{-1} (\mathbf{y} - \tilde{h}(\mathbf{x}))$$

$$= (\mathbf{x}_b - \mathbf{x})^T \mathbf{B}^{-1} (\mathbf{x}_b - \mathbf{x}) + (\mathbf{y} - \tilde{h}(\mathbf{x}))^T \mathbf{R}^{-1} (\mathbf{y} - \tilde{h}(\mathbf{x}))$$

$$+ (\hat{\mathbf{a}}_b - \hat{\mathbf{a}})^T \mathbf{B}_{\hat{\mathbf{a}}}^{-1} (\hat{\mathbf{a}}_b - \hat{\mathbf{a}})$$

# VarBC Settings

- Predictors (p)
  - WILR/TCPW,  $T_{SRF}$ ,  $T_{SRF}^2$ ,  $WS_{SRF}$ ,  $1/\cos(Z_{ANG})$ , 1(Const)
- Back Ground Term ( $\beta_b$ )
  - The Last  $\beta$
- Back Ground Error (  $B_\beta$  (  $\sigma_\beta$  ) )
  - Do Not Considering the Correlations among Predictors
  - N: Observation Data Number
    - Original
    - Our Settings

WILR: Weighted Integrated Lapse Rate ← For AMSU-A

TCPW: Total Column Precipitable Water ← For AMSU-B, MWRT

$$\sigma_\beta = \sigma_{obs} / N$$

Obs ~ Bkg

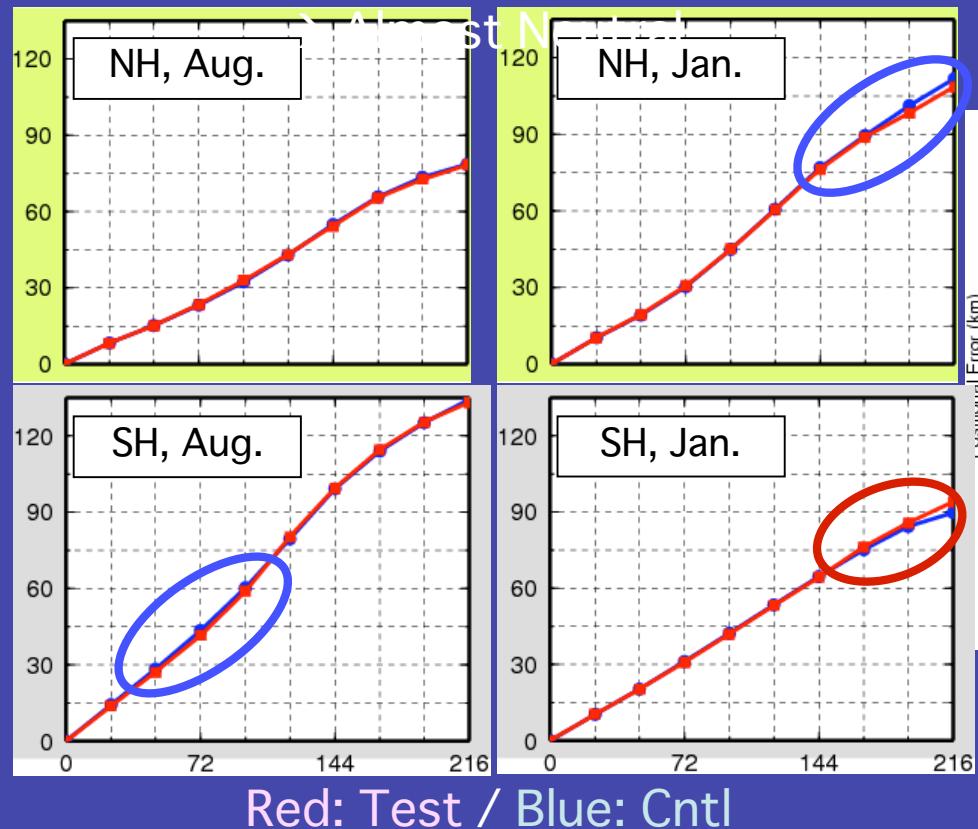
$N < N_{MIN} \rightarrow Bkg > Obs$   
 $N = N_{MIN} \rightarrow Bkg \sim Obs$   
 $N > N_{MIN} \rightarrow Bkg < Obs$

$$\sigma_\beta = \begin{cases} \sigma_{obs} / N_{MIN} & N < N_{MIN} \\ \sigma_{obs} / (N / (\log_{10}(N / N_{MIN}) + 1)) & N \geq N_{MIN} \end{cases}$$

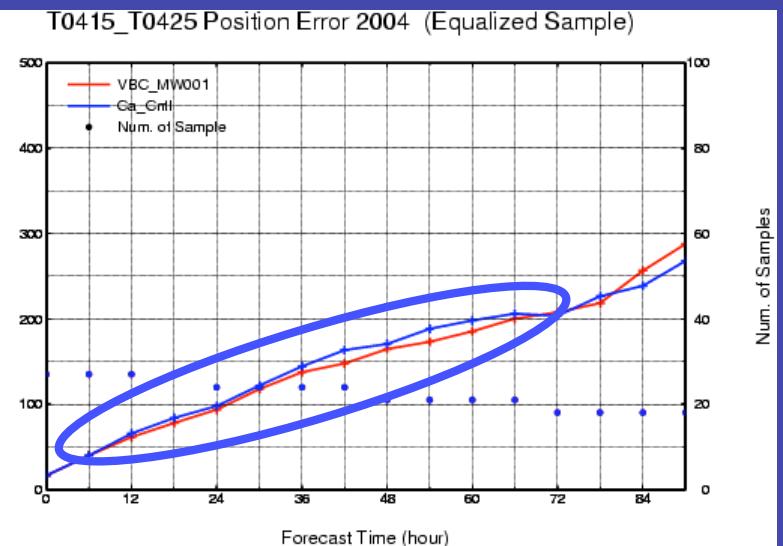
$N_{MIN} = 400$

# OSE results

500hPa GPH forecast RMSE time sequence



Typhoon position error time sequence  
→ Improved

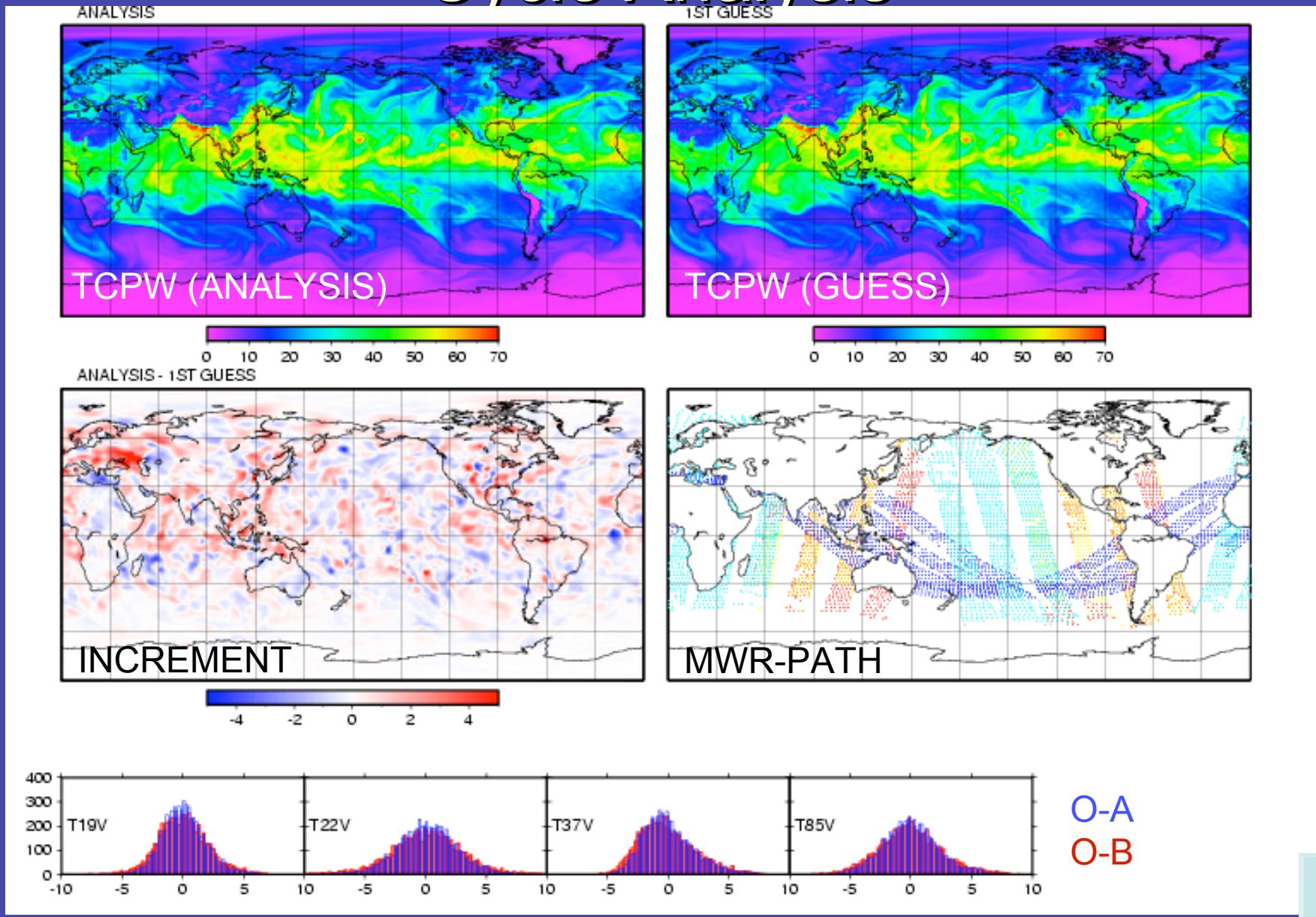


Red: Test / Blue: Cntl

With the results, JMA decided to use MWR radiances in the operational Global Analysis.

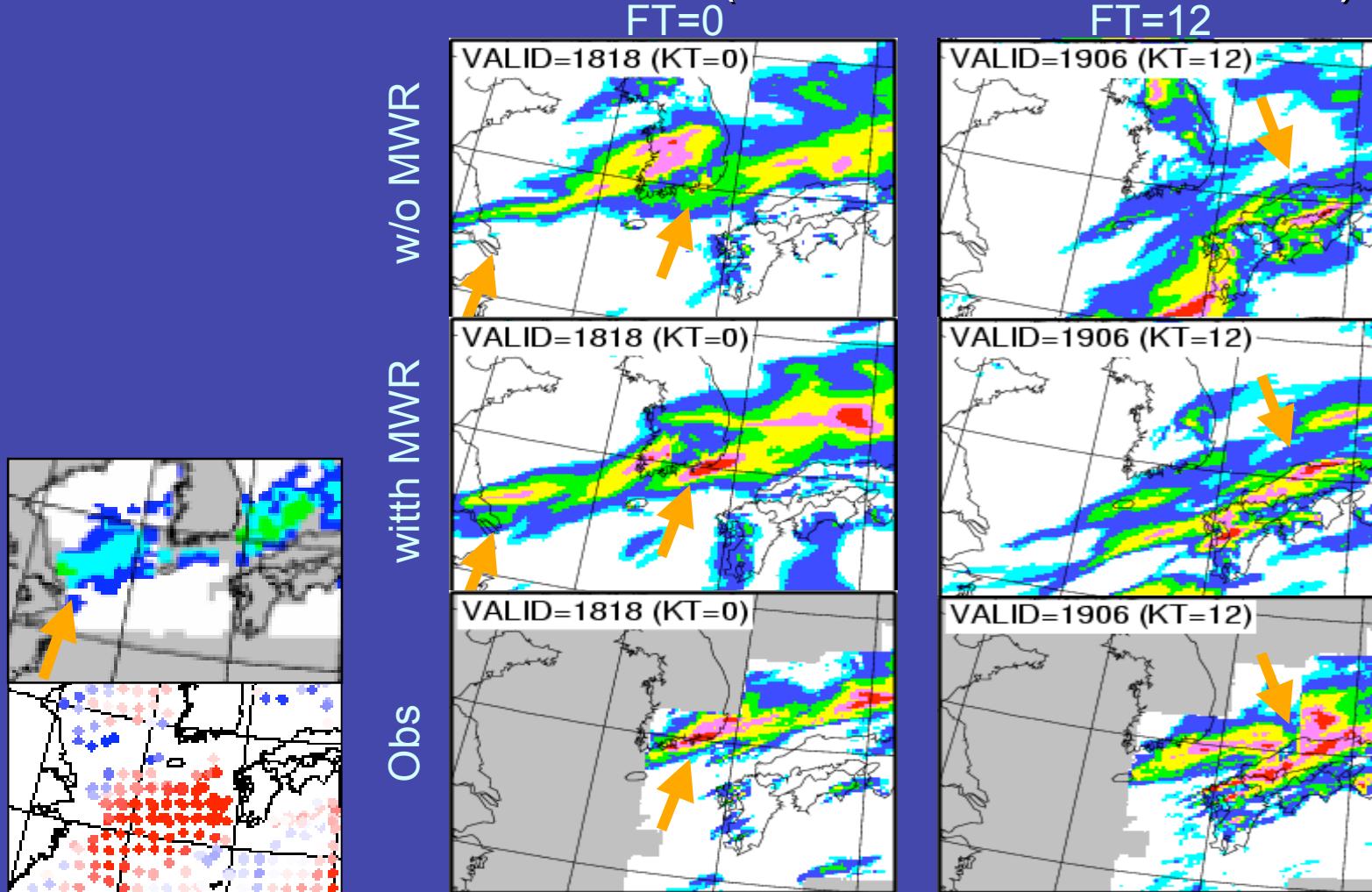


# Cycle Analysis



# Sample Case for MSM

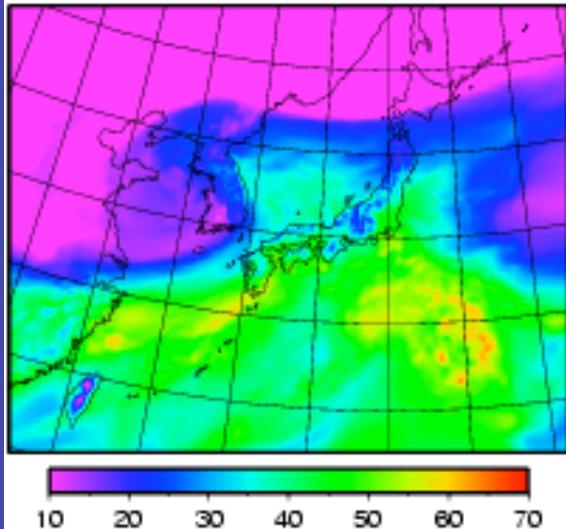
- 18 Jun. 2001, 18UTC Initial (3 hour accumulated rain)



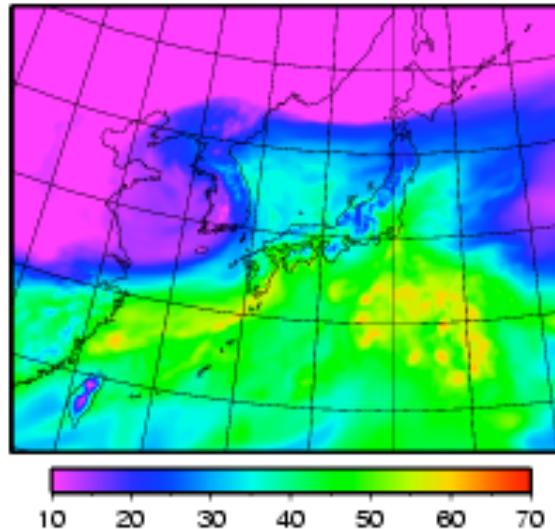
# Assimilation Sample for MSM

IMPACT OF MW-PW (2006102218)

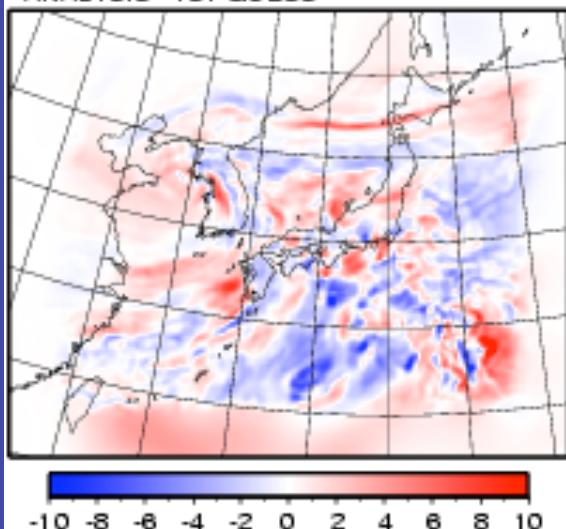
ANALYSIS



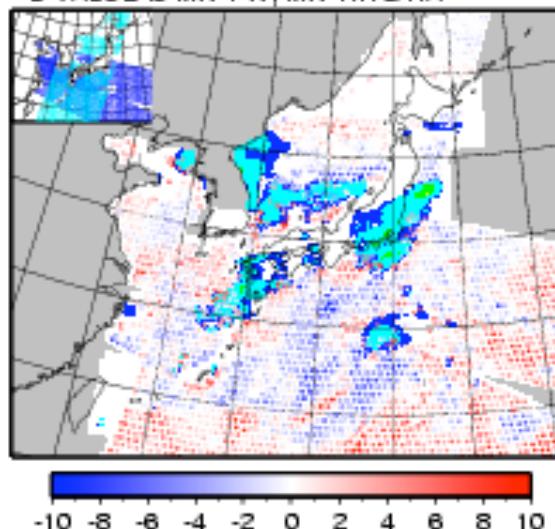
1ST GUESS



ANALYSIS - 1ST GUESS

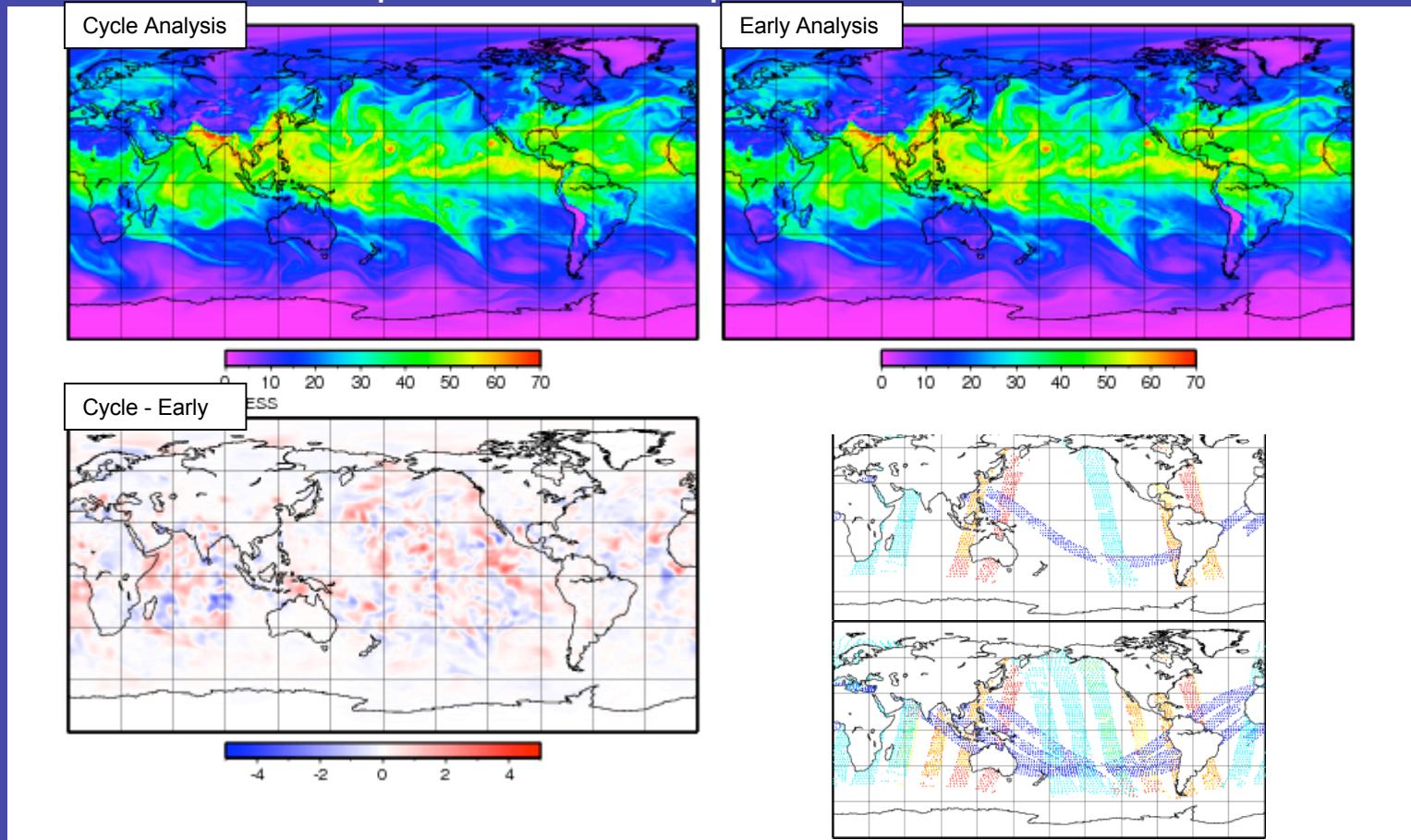


D-VALUE to MW-PW, MW-RR & RA



# Difference between the Analyses

Impact on the Precipitable Water Fields



The difference shows late delivery data impact.  
The impact of the MWR on the PW fields was very Large.





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